The Great Primordial force owes its genesis to the initial impulse which set all spheres in motion in vacuous space. To this universal principle, not only all physical force, but new life itself is due.

HUMBOLDT says: "It is indeed a brilliant effort, worthy of the human mind, to comprise in one organic whole the entire science of nature, from the law of gravity to the formative impulse in animated bodies."

That the earth, and the sun, and all the heavenly bodies, are possessed of the mysterious magnetic energy, and consequently exert a powerful magnetic influence over each other, has long ago been conceived by such men as HERSCHEL, HUMBOLDT, FARADAY; and is the faith of scientists to-day. But when we have arrived at such a conclusion, it is impossible for us to stop short, and not make the necessary deductions therefrom. Mighty magnets, when involved in mighty motions, must produce mighty currents and mighty effects. It is not for nothing that these powers and conditions exist. If we admit the premises, we must not ignore the conclusions that are necessitated. Provision must be made for the outcome of every admitted fact in science.

Therefore, it is with assurance that we urge the electric theory, and maintain that the burden of proof rests with those, who, admitting the elements of motion and magnetism, have yet made no provision whatever for their keeping.

Besides, there are two other principles already alluded to—the conservation of force, and the unity of all the forces—with respect to which it may be demanded, to what other result do they lead, and can they lead, in all reason and logic, than to the admission of the grand fact of a Great Primordial Force.

THE TIDAL EVOLUTION OF THE MOON.

On Saturday, June 4th, in the Museum Buildings, Trinity College, Dr. Ball, Astronomer Royal for Ireland, delivered an interesting and instructive lecture on recent discoveries in astronomical science. Dr. Ball said that from the variety of topics which might fairly be dealt with in his lecture he would select three, and in making this selection he had been mainly guided by the relative importance of different astronomical problems. He had also endeavored to exercise his choice so that his lecture should, as far as possible, refer to the various branches of astronomy. Having dealt with two branches of his subject, Dr. Ball described "Darwin's Theory of the Tidal Evolution of the Moon." It had, he said, been the triumph of modern gravitational astronomers to indicate the changes which must be going forward in a system devoid of rigidity. It was at all events easy to show that the tendency of these changes lay in one direction, and this was the most important point for consideration. Everyone was aware of the daily movements of the sea, which were called the tides. Most people were aware that the movements of the waters were caused by the attraction of the sun and the moon. Let them ponder therefore on the tides, as they seemed to give a clue to some of the profoundest of nature's secrets. He had heard that the port of Dublin was gradually being improved by the deepening of the bar. He had heard that the deepening of the bar had been attributed to the judicious action of the Port and Docks Board. But what the board had chiefly done was to call into requisition the scouring power of the tide, which, as he was informed, was gradually reducing or bearing away the bar. The tide was therfore accomplishing, at the bar of Dublin, the same kind of work as could be accomplished by men or by steam-engines. In other words, the tide was here doing a useful work that could otherwise only be done by the expenditure of energy. It was the same elsewhere. The tides were doing work useful or the reverse, and expending energy in so doing. Where did the energy come from? It could not be created. It could only come from the store of energy available for such purposes in the solar system. The reserve energy whence the tides drew the supplies they were daily consuming consisted partly in the daily rotation of the earth on its axis. The earth was like a mighty flywheel which would absorb a prodigious amount of energy in setting it in motion, and which would give out that energy before it would be brought to rest. The rotation of the earth on its axis was a vast but not inexhaustible storehouse of energy, on which the tides could draw for thousands of years. Energy also existed in the solar system in many other forms, some of which could also be rendered available for the tides. So far as was known, the total amount of energy could not be increased. The important question was—Can that total ever be diminished? The tides were diminishing it every day. The small oceanic tides were not the sole source of the expenditure. The solid body of the earth itself must be subject to tides; still more must the fluid or gaseous members of our system be subjected to tides. All tides involved friction, and all friction involved loss of energy. Here, then, was the great discrepancy between the theory of Lagrange and the actual condition of our system. Lagrange's calculations assumed that the total energy of the solar system was constant, but the actual fact was that the energy was slowly diminishing. The tracing of tidal evolution was chiefly due to the labors of Mr. G. H. Darwin, son of the celebrated naturalist. The influence of the tides had already been recognized as the cause of the same face of the moon being always bent on the earth. Whether the tides were merely oceanic, or whether they were actual bodily tides, the results remained much the same. At the present time the moon revolved around the earth in a month: the earth revolved on its axis in a day. The tides produced in the earth by the moon must act to reduce the rate of the earth's rotation. The effect of the tides on the earth was to lengthen the day. The day was gradually lengthening, but this change could not take place without a reactionary change on the moon. The change undergone by the moon was perhaps a little difficult to understand, as it depended on some by no means simple dynamical principles. The friction of the tides consumed the energy of the system. It turned a large portion of that energy into heat, which was then radiated off into space to be forever lost. But the friction of the tides could not alter the moment of momentum of the system. As the earth became gradually slower and slower in its rotation its moment of momentum decreased, yet for this to happen the moment of momentum of the moon should increase. It followed mathematically that as the tides gradually made the earth rotate more and more slowly, the moon must be getting farther and farther away from us. At the end of a million years from the present time the day will be more than one day of twenty-four is now; and in one million years hence the moon will move round the earth at a greater distance than she does now, and the length of the month will be correspondingly increased. In the far distant future therefore, we are to look for an increased length of month. The length of day will, however, increase much faster than the length of the month, until at length the duration of the day equals that of the month. When this time arrives the moon w ll have moved out to a distance half as great again as it is at present, and the length of the month will have increased to two months. Our day will then have increased from twenty-four hours up to nearly two months. and as the moon continues to to show the same face to us, we are destined to turn the same face on the moon. Were the earth and the moon the only bodies in the universe, such a state of things might go on forever. The sun, however, will produce tides in the earth which will again modify their movements. He had said that the moon was gradually receding farther and farther from the earth, and that the

length of the day was increasing—getting gradually longer and longer. But how long has this been going on? Yesterday was shorter than to-day. The day which Homer had was shorter than our day, but not indeed to any appreciable extent. There can be no doubt, however, that a million years ago the day was appreciably shorter than the day is at present. He wished to conduct them back to an exceedingly remote period, to a critical epoch in the history of the earth. That epoch must have been more than fifty millions of years ago, but how much more he could not tell. At that extremely remote time the day was greatly less than it is at present. It was only, indeed, a fraction of its present amount, being only from two to four hours long. He would trace back the moon to the same remote epoch to which he had conducted the earth. The tides in the earth are forcing the moon gradually away from us at present. The moon was therefore formerly nearer to us than it is now. Millions of years ago the orbit of the moon was much less than it is at present. The time of the moon's revolution was much smaller and the moon must have been quite close to the earth, and whirled round the latter in a period of from two to four hours equal to the period of the earth's revolution on its axis. Such, then, is the primeval condition of things to which the tracing of tidal evolution conducted. Antecedent to this critical epoch they could hardly go with any degree of certainty. After explaining Darwin's theory in reference as to the supposed rupture of the earth at a very remote period of time, and the consequent formation of the moon, the lecturer proceeded to speak of the surprise with which astronomers realized that the small interior satellite of Mars revolved on its axis in less than a third of the time —nearly 24 hours—which the primary occupied in revolving on its own axis. He also spoke of the tremendous forces in action at remote periods when tides rose to a height of a thousand or two thousand feet, scouring rocks and carrying enormous quantities of matter to the sea, and when that action caused so much comparatively rapid manufacture of strata.

MR. DARWIN ON DR. HAHN'S DISCOVERY OF FOSSIL ORGANISMS IN METEORITES.

Dr. Hahn's discovery, of which an elaborate account was given in No. 50 of SCIENCE, has stirred up a lively discussion of this highly interesting subject. Dr. Hahn has taken steps to enable Prof. von Quenstedt, the renowned Tübingen geologist, and all others who expressed the desire to examine his microscopic preparations. It is understood that all those who have availed themselves of the opportunity thus offered have become convinced of the genuineness of Dr. Hahn's discovery.

It is very interesting to note the position taken by the greatest of living evolutionists in this controversy, if it can still be called such. Charles Darwin, on receipt of Dr. Hahn's work, wrote to him:

" . . . It seems to be very difficult to doubt that your photographs exhibit organic structure . . . ," and furthermore:

" . . . your discovery is certainly one of the most important."

Not content with the mere presentation of his work, Dr. Hahn visited the veteran zoologist and brought his preparations to him for inspection.

No sooner had Mr. Darwin peered through the microscope on one of the finest specimens when he started up from his seat and exclaimed:

" Almighty God! what a wonderful discovery! Wonderful!"

And after a pause of silent reflection he added:

" Now reaches life down!"

The latter remark no doubt refers to the proof furnished by Dr. Hahn's discovery that organisms can reach our planet from celestial space. It is an acknowledgment of the relief Mr. Darwin must have felt in not being forced to a belief in a primeval "*generatio equivoca*."

As was suggested in the paper referred to, "the Richter-Thomson hypothesis of the origin of life on the earth has become a tangible reality!" R.

AN AFTERNOON ON PASSAIC RIVER.

On the 25th day of last month the editor, in company with his former colleague on the *Quarterly*, Mr. J. L. Wall, escaped from the city and made a trip to the town of Belleville, on the Passaic River. A row-boat was engaged, and we proceeded to collect specimens from along the shores. Not many species of algæ were found, nor was there any great variety of animal forms, but the water-plants, so hardy and useful in aquaria, the *Anacharis Canadensis* and *Vallisneria spiralis*, were abundant. Reaching over into the shallow water, it was an easy matter to obtain perfect plants of *Vallisneria* with good roots, and we collected a number of them. The *Anacharis* grows so readily without roots that the more fresh looking stems were carried home without regard to the roots. An old can was made use of to carry home some of the river mud, in which to plant the *Vallisneria*. The mud was placed in the bottom of a tall specie jar, the roots of the plant were properly embedded, and the jar filled with water. The next morning, after the water was cleared by settling, the mud was covered with a layer of clean sand, which tends to prevent riling of the water by a slight disturbance. All the leaves of the *Vallisneria* were removed, so that a new growth might start in the aquarium. It is probable that we will thus obtain some vigorous plants of *Vallisneria* for use during the coming winter. The *Anacharis* was simply thrown into a large aquarium, where it will doubtless grow without further care. Rowing about slowly, a long, green, spiral filament was observed reaching up to the surface of the water. It was two or three feet in length, and bore a peculiar flower at the end. This was the female flower of *Vallisneria*, a very interesting object for study; it was quite a surprise to us, as the plant does not usually flower as early as July. Looking toward the shore, the water was covered with an innumerable quantity of white specs, which attracted our curiosity. Rowing up to them, we found that they were the male flowers of *Anacharis*. These are very curious flowers. The long, tubular perianth, sometimes two or three inches in length, reaches from the axil of a leaf to the surface of the water, and bears the stamens above. It would easily be mistaken for the flower-stem, but it is really the tubular perianth. These flowers were very abundant, so that the water appeared white with them. The pollen-grains were numerous, and could be seen floating about on the water in little clusters resembling snow-flakes. *Potamogeton* was abundant, in several forms, and the common arrow-plant, so named from the shape of the leaf, *Pontedaria cordata*, which is also good for large aquaria. This plant should be set in a flower-pot, with suitable soil in which to root, and then submerged, either wholly or in part.

Among the algæ, two species of Oscillaricaceæ were found quite actively moving *Oscillaria tenius* and *littoralis*, and *Lyngbya majuscula*. The most interesting specimen of all, however, was a species of *Ulothrix*, a very common, filamentous, green algæ, in which the cells are about as long as they are wide. It was interesting because when we examined it, at about seven o'clock the next morning, the process of giving off swarm-spores had just begun. The entire contents of each cell in whole filaments, quickly formed into green, spherical masses, which began to move about in the confined space within the cells; soon the cell-walls ruptured, and the contents escaped as very active swarm-spores, somewhat elongated in form, and furnished with four long, whip-like appendages, or flagella, by means of which they could